Self-assembly of hollow bismuth ferrite spheres

A.V. Dmitriev, E.V. Vladimirova, M.V. Kandaurov

Institute of Solid State Chemistry, Urals Branch of the Russian Academy of Sciences, 620990, Ekaterinburg, Russia
dmitriev@ihim.uran.ru

The development of novel approaches to the control of the architecture of nanoparticle sets by means of affecting self-assembling is the crucial task of modern science. This can be achieved using the theory of self-organization in dissipative systems, thus providing a basis for creating future prospective materials. The identification of contributions of various factors in self-assembly processes and physical modeling can assist in developing approaches of expectable impact a reacting system to design modern materials with outstanding properties and morphology.

In this paper, we promote the novel technique of controllable self-assembly during ultrasonic spray-pyrolysis. This method allows for obtaining spherical particles consisting of different materials. In particular, we evaluate ultrasonic spray-pyrolysis for the production of $BiFeO_3$ (BFO) microspheres due to recent attention to this material.

The theory of the spray-pyrolysis is based on the model of drying droplet containing given insoluble content. The reaction system holds two contrary processes while the solvent is evaporating from the droplet surface. The first process is connected with the decrease of droplet size; the second consist of the alignment of content concentration within droplet due to diffusion. Depending on the leading process described above there can be formed solid agglomerates or hollow spheres which also can have both close and open porous. However, adjustment of drying temperature and solution concentration are not the only factors to affect the phase morphology. To the best of our knowledge metal ions tend to form chelate compounds with tartaric acid. Moreover, the presence of complex metalorganic compounds in a reaction system leads to the significant decreasing of the ion diffusion velocity and as a result, there can be obtained spherical particles with a thin wall.

We synthesized BFO powders by the spray-pyrolyzing of the water solution of iron and bismuth nitrates with tartaric acid. Prepared samples were characterized as single-phase due to X-ray analysis. The morphology of obtained BFO powders seems to be dependent on drying temperature. Furthermore, morphology tends to vary if solution concentration or the amount of tartaric acid is adjusted.

Morphology seems to affect the magnetic properties of BFO powders. Physical parameters such as wall thickness, the package density of crystallite units, and the grain size in agglomerates appear to be crucial that define the magnetic behavior of BFO powder.

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